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Gas Diffusion Electrodes for PBI Cells

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Acid doped polybenzimidazole (PBI) membranes have been suggested as electrolyte for proton exchange membrane fuel cells (PEMFC)[1] and received great attention, as recently reviewed.[2-4] Fuel cell tests have been performed with different types of fuels such as hydrogen, hydrogen containing CO[5], methanol[6] and others. Methods for preparing gas diffusion electrodes and membrane-electrode assemblies (MEAs) with PBI membranes have been developed by several groups. The gas diffusion electrodes were constructed with PBI as the catalyst binder or, when PTFE was used as the catalyst binder, the electrodes were impregnated with PBI. The loading of the polymer in the catalyst layer is a key parameter. The PBI containing electrodes are then doped with phosphoric acid to order to improve the proton conductivity.

In this work a tapecasting method is used for preparing gas diffusion electrodes for PBI cells. The total porosity of electrodes was changed from 43% to 64% with help of porogens as additives to the catalyst slurry for electrode casting. The porosity of gas diffusion electrodes is determined by absorbing toluene into the electrodes under vacuum and measuring the weight change of the electrode samples. Fig.1 shows the porosity variation of the gas diffusion electrodes made from slurries containing various porogens. Of the selected porogens, ammonium oxalate seems to be an effective one. It decomposes completely during the drying of electrodes at 250°C and gives an improved overall porosity from 43% to above 60%. ZnO is also effective, however, it should be removed afterwards by washing electrodes with dilute sulfuric acid.

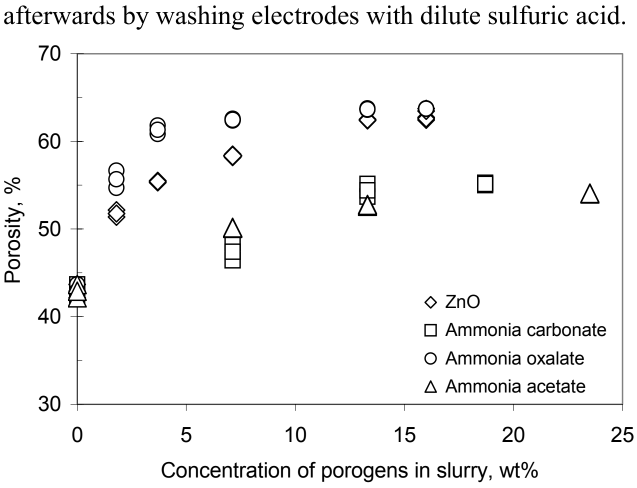

Fig.1. Total porosity of gas diffusion electrodes tapecast from slurries containing various types of porogens.

The performance of fuel cells with electrodes of varied porosities was investigated at temperatures up to 200°C. The used fuel gases are pure hydrogen and hydrogen containing 25% CO_2 and the oxidant is either oxygen or air. The operational pressure was changed from ambient to 4 bars on both anode and cathode sides.

Fig. 2 shows a set of polarizations curves obtained from such made electrodes with an overall porosity of 43% and 62%, respectively, operating on both oxygen and air at the cathode.

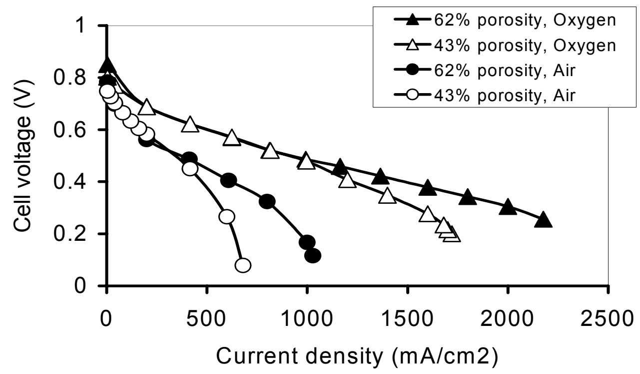

Fig.2. Polarization curves of a PBI fuel cell under ambient pressure at 200°C. The platinum loading of each electrode was 0.6 mgPt/cm^2. The electrode area was 25 cm^2 with a gas flow rate of 24 L/h^1 for hydrogen and oxygen, 48 L/h^1 for air.

Fig.3 shows polarizations curves obtained with electrodes of 64% porosity. With O_2 at cathode, no limiting current is observed at current densities of 2.5 A/cm² and hydrogen utilization of over 93% from a mixture of 75%H_2-25%CO_2.

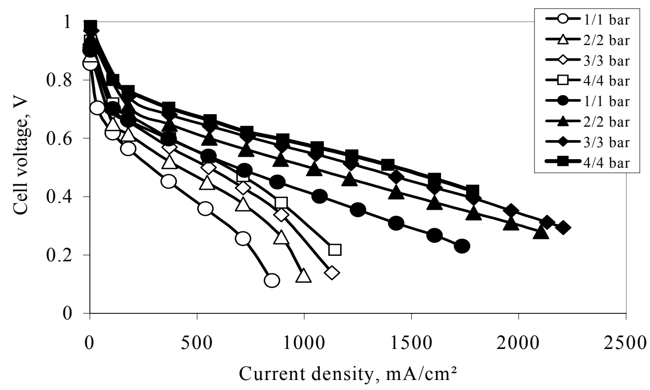

Fig.3. Polarization curves of a PBI cell under different pressures at 200°C. Fuel: 25%CO_2-75%H_2; Oxidant: open symbols for air and solid symbols for O_2; Active electrode area: 25 cm^2; Pt loading: 0.6 mg/cm^2; Overall electrode porosity: 64%; Fuel flow: 10 L/h; O_2 flow: 4 L/h; Air flow: 8 L/h.

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